Creating a Custom Interface for X10 Home Automation

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EXECUTIVE SUMMARY

Home automation control is an area that is nearly endless in possibilities. However, most software that is designed for home automation is limited and doesn't provide desired features to the user. This application note discusses the basics of home automation with X10 modules and shows how to create a simple form that will allow the user to control the X10 home automation modules.

KEYWORDS

Home automation, X10, firecracker, CM17A

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1. Introduction

Home automation gives consumers the ability to control their appliances without having to be physically near them. The control can come from either hardware or software based applications. The provided software suites usually limit consumers on what can be achieved. This application note will discuss the ability to set up and create a basic interface for home automation using X10 modules.

2. Background

2.1 X10 Operation:

The interface that will be described will use the X10 units for home automation. The X10 Firecracker RF module will send signals to a plugged in X10 Transceiver that will then use power line carrier (PLC) communication to send signals to other X10 units plugged into different outlets. Each unit is assigned a house code and unit number; this is done on a set of dials on the unit.

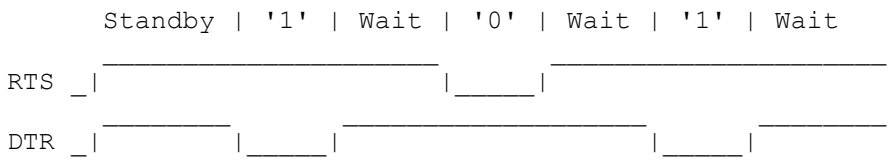
2.2 X10 Firecracker:

The X10 Firecracker does not send a signal like a normal serial output. Instead of using the dedicated data lines it uses the RTS and DTR pins on the serial port. This allows a second serial device to be connected onto the firecracker as long as the second device does not need the RTS and DTR pins.

The Firecracker is powered by keeping either the RTS or DTR line high or logical ‘1’. When communication is done it takes place in the following manner:

Signal	RTS	DTR
Reset	0	0
Logical ‘1’	1	0
Logical ‘0’	0	1
Standby	1	1

One important note is that when trying to send a signal through firecracker unit, either the RTS or DTR lines needs to remain high to ensure the signal gets sent and the unit isn’t reset. This is ensured by allowing a .5ms delay between signals. A typical signal would look like this:



Obtained from Firecracker User Manual

2.3 X10 Protocol:

The communication done from the Firecracker unit to the transceiver has a protocol that must be followed.

Each command that is transmitted must include a 16-bit header and 8-bit footer with the user’s desired 16-bit command signal in between totaling 40-bits.

|Header| |User Command| |Footer|

The binary number for the header and footer are:

Header:	11010101 10101010
Footer:	10101101

The commands that actually make the different units turn on and off are contained in the 16-bit middle part of the protocol. The following breaks apart each bit.

Byte 1	Byte 2
X X X X 0 X 0 0	X X X X X 0 0 0
1 2 3 4 5 6 7	8 1 2 3 4 5 6 7 8

Byte 1

1: One for house codes E-L
2: One for house codes A-D & I-L
3: One for house codes A,B,G,H,I,J,O,P
4: One for house codes B,D,F,H,J,L,N,P
5: Always zero
6: One for units 9-16
7: Always zero
8: Always zero

Byte 2

1: One for BRIGHT or DIM
2: One for unit codes 5-8 & 13-16
3: One for OFF (Zero for ON or BRIGHT/DIM)
4: One for unit codes 2,4,6,8,10,12,14,16 & DIM command
5: One for unit codes 3,4,7,8,11,12,15,16 & BRIGHT & DIM commands
6: Always zero
7: Always zero
8: Always zero

The complete list of codes for X10 units is located in Appendix A.

3. Components Required

There are a few parts that are going to be needed in order to create a basic interface for home automation.

X10 Transceiver: This unit will be the unit that receives the signal from the computer and sends out the PLC signal to the other X10 modules.

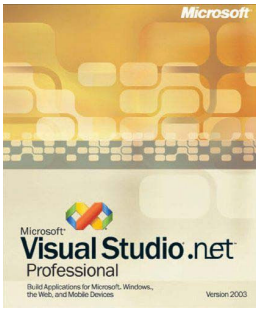
X10 Appliance/Lamp Module:

Depending on specific applications either can be used in the process.

Firecracker: This is the transmitter that will send the data from the computer to the X10 transceiver. It is important to get the CM17A model.

Computer: This to run the home automation interface, as well as using it for the programming software.

Visual Studio .NET: This is the software suite that will be used to program the user interface. Examples will be from the 2003 edition.



***(Optional)* USB to Serial Adapter:**

If there is not an available serial port on the host computer that will run the interface. Make sure that the DTR and RTS pins can be used.

Step 1)

Create a new form. Open up Visual Studio .NET and start a new project as in Figure 4.1.

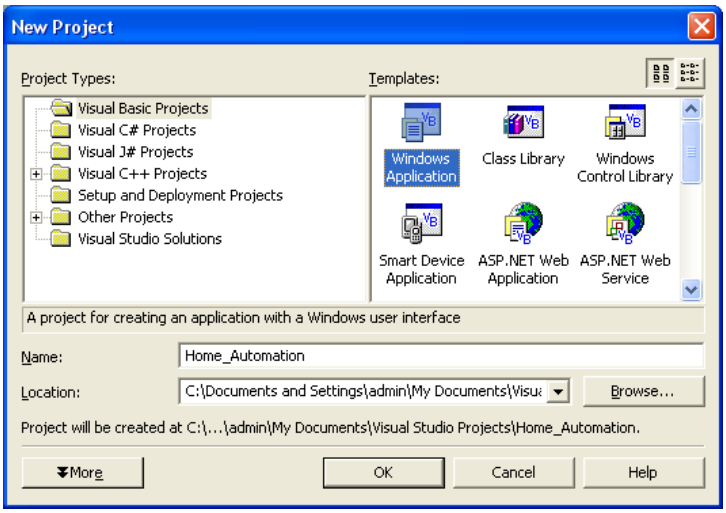


Figure 4.1 – New Project Dialog Window

Step 2)

Make the interface. Next, add two buttons, two text boxes and two labels to the form. It should look like Figure 4.2.

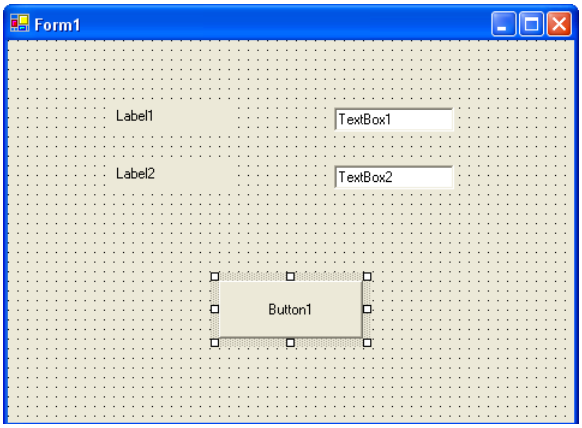
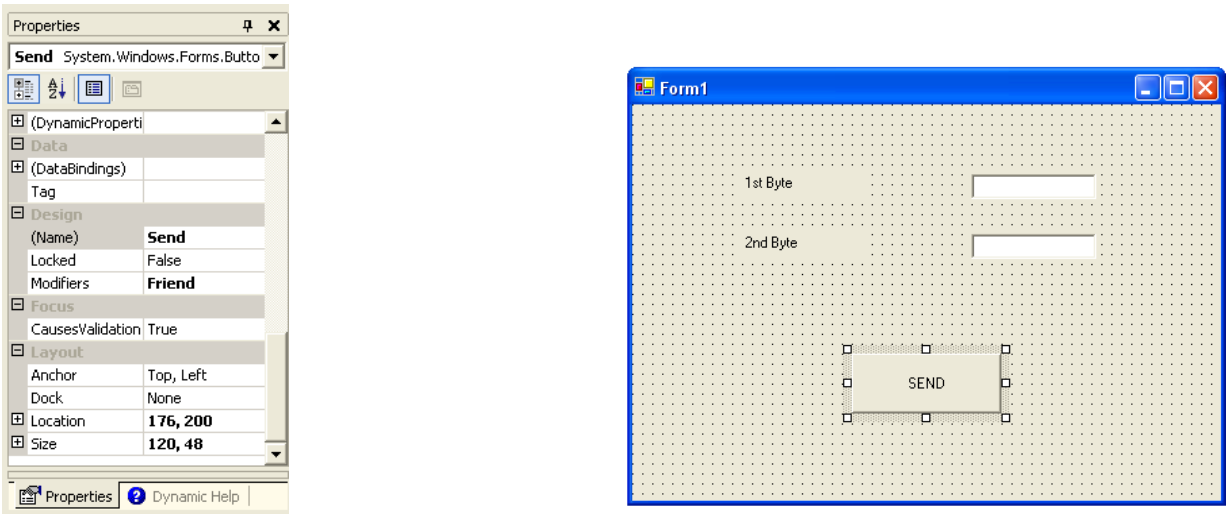


Figure 4.2 – New form with added features

It is then advised that the text and names are changed to something more useful. Figure 4.3(a) shows what the button's name should be changed to. In the same menu of the respective components the displayed text can be changed. Figure 4.3(b) shows what the form should look like at this point.



(a) **(b)**

Figure 4.3 – Properties menu and final form design

Step 3)

Add serial communication. This will enable the form to communicate through the serial port. First, a file CRs232.vb will be needed. It can be downloaded here: www.codeworks.it/net/rs232.zip. Then unzip the file, and go back to the form and click Project → Add Existing Item, and browse for the CRs232.vb. Wherever the rs232.zip was unzipped is where this file will be located.

Step 4)

Setting up the code. Double click anywhere on the form where there is open space. The first code that will be entered is the form load event code and global statements. Enter the code in Figure 4.4 as it appears in the figure. However, the .Port setting should be changed to the appropriate value. The COM port number can be obtained through the device manager.

```
Public Class Form1
    Inherits System.Windows.Forms.Form
    'Add these two lines!
    Private Declare Sub Sleep Lib "kernel32" (ByVal dwMilliseconds As Long)
    Dim setRs232 As New Rs232

    Windows Form Designer generated code

    Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles MyBase.Load

        With setRs232
            .Port = 5
            .BaudRate = 9600
            .DataBit = 8
            .StopBit = Rs232.DataStopBit.StopBit_1
            .Parity = Rs232.DataParity.Parity_None
            .Timeout = 10000
            .Dtr = True
            .Rts = True
        End With
        setRs232.Open()
        Sleep(50)
        setRs232.Rts = False
        setRs232.Dtr = False
        Sleep(50)
        setRs232.Rts = True
        setRs232.Dtr = True
        Sleep(50)
    End Sub
```

Figure 4.4 – Form load and global statements

Next, scroll down to the bottom of the code window. Right before the End Class statement enter the code from Figure 4.5. This is the function that turns the binary data into signals to be sent through the Firecracker unit. The way it is set up is it iterates through each part of the string that is passed in and determines if it is 1 or 0. Then it changes the DTR or RTS pin respectively. It then waits .5ms to accommodate the

necessary delay and then turns the pin back on. This ensures that the unit will always have a pin high so it doesn't reset at an incorrect moment.

```
Public Function SendBits(ByVal Transmission As String)
    Dim i, j As Long
    Dim SendBit As Integer
    For i = 1 To Len(Transmission)

        SendBit = Val(Mid$(Transmission, i, 1))
        If SendBit = 1 Then
            setRs232.Dtr = False
            Sleep(0.5)
            setRs232.Dtr = True
        Else
            setRs232.Rts = False
            Sleep(0.5)
            setRs232.Rts = True
        End If


    Next i
End Function
```

Figure 4.5 – Send function

Now the button click code needs to be entered. Every time the button is clicked it will send out the 2-bytes through the Firecracker to the X10 Transceiver, this is what will enable the home automation.

Go back to the form and double click on the send button. This will automatically open up the proper place to enter the click code. Enter the code from Figure 4.6.

```
Private Sub Send_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Send.Click

    'Header - This is Always the same
    Call SendBits("11010101")
    Call SendBits("10101010")

    'User Data - This changes with each send
    Call SendBits(TextBox1.Text)
    Call SendBits(TextBox2.Text)

    'Footer - This is Always the same
    Call SendBits("10101101")
End Sub
```

Figure 4.6 – Button click code

Step 5)

Install X10 modules. At this point, the software should be completed. Now the X10 units need to be installed. The transceiver should be near the computer for the best reception. The other units can be located anywhere else in the house. However, make sure all their house codes are the same and each of their unit numbers are different. The transceiver X10 module will always be unit 1.

Step 6)

Home automation. Return to the home automation form. Click Debug → Start Debugging. In the first text box enter "01100000" and "00000000" into the second; be sure not to include the quotes. Then click send. The transceiver unit should then have turned on. If not, click the manual switch on the transceiver and try again.

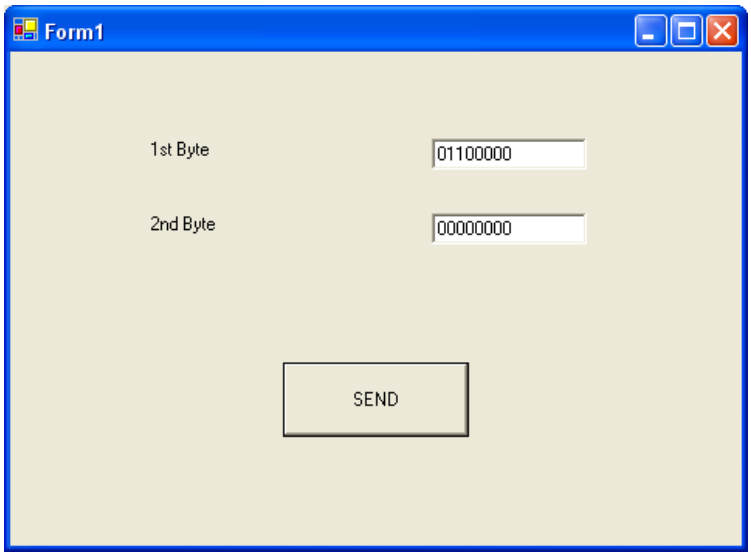


Figure 4.7 – Form contents to turn on transceiver

5. Results

The form that was created can now be used to control any X10 unit in the home. Using the data from Appendix A, the user can choose exactly what they want to happen. Just enter the first 8-bits into text box 1 and the second 8-bits into the second text box and hit send.

6. Conclusion

This application note shows how to create a basic form to use in X10 home automation. With what has been provided, it is possible to send commands to any unit using the specific binary codes that belong to that unit and action to be carried out. From here, the user can create custom, in-depth applications that are suited to their needs.

7. References

"CM17A Protocol." *X10*. N.p., n.d. Web. 31 Mar 2010. <ftp://ftp.x10.com/pub/manuals/cm17a_protocol.txt>.

Davis, Adam. "CM17A Protocol." *Adam Davis*. N.p., 25 Jan 2008. Web. 31 Mar 2010. <http://www.ubasics.com/adam/electronics/cm17.shtml>.

8. Appendix A

A1 ON	01100000	00000000
A1 OFF	01100000	00100000
A2 ON	01100000	00010000
A2 OFF	01100000	00110000
A3 ON	01100000	00001000
A3 OFF	01100000	00101000
A4 ON	01100000	00011000
A4 OFF	01100000	00111000
A5 ON	01100000	01000000
A5 OFF	01100000	01100000
A6 ON	01100000	01010000
A6 OFF	01100000	01110000
A7 ON	01100000	01001000
A7 OFF	01100000	01101000
A8 ON	01100000	01011000
A8 OFF	01100000	01111000
A9 ON	01100100	00000000
A9 OFF	01100100	00100000
A10 ON	01100100	00010000
A10 OFF	01100100	00110000
A11 ON	01100100	00001000
A11 OFF	01100100	00101000
A12 ON	01100100	00011000
A12 OFF	01100100	00111000
A13 ON	01100100	01000000
A13 OFF	01100100	01100000
A14 ON	01100100	01010000
A14 OFF	01100100	01110000
A15 ON	01100100	01001000
A15 OFF	01100100	01101000
A16 ON	01100100	01011000
A16 OFF	01100100	01111000
A BRIGHT 005	01100000	10001000
A DIM 005	01100000	10011000
B1 ON	01110000	00000000
B1 OFF	01110000	00100000
B2 ON	01110000	00010000
B2 OFF	01110000	00110000
B3 ON	01110000	00001000
B3 OFF	01110000	00101000
B4 ON	01110000	00011000
B4 OFF	01110000	00111000
B5 ON	01110000	01000000
B5 OFF	01110000	01100000
B6 ON	01110000	01010000
B6 OFF	01110000	01110000
B7 ON	01110000	01001000
B7 OFF	01110000	01101000
B8 ON	01110000	01011000
B8 OFF	01110000	01111000
B9 ON	01110100	00000000
B9 OFF	01110100	00100000
B10 ON	01110100	00010000

B10 OFF	01110100	00110000
B11 ON	01110100	00001000
B11 OFF	01110100	00101000
B12 ON	01110100	00011000
B12 OFF	01110100	00111000
B13 ON	01110100	01000000
B13 OFF	01110100	01100000
B14 ON	01110100	01010000
B14 OFF	01110100	01110000
B15 ON	01110100	01001000
B15 OFF	01110100	01101000
B16 ON	01110100	01011000
B16 OFF	01110100	01111000
B BRIGHT 005	01110000	10001000
B DIM 005	01110000	10011000
C1 ON	01000000	00000000
C1 OFF	01000000	00100000
C2 ON	01000000	00010000
C2 OFF	01000000	00110000
C3 ON	01000000	00001000
C3 OFF	01000000	00101000
C4 ON	01000000	00011000
C4 OFF	01000000	00111000
C5 ON	01000000	01000000
C5 OFF	01000000	01100000
C6 ON	01000000	01010000
C6 OFF	01000000	01110000
C7 ON	01000000	01001000
C7 OFF	01000000	01101000
C8 ON	01000000	01011000
C8 OFF	01000000	01111000
C9 ON	01000100	00000000
C9 OFF	01000100	00100000
C10 ON	01000100	00010000
C10 OFF	01000100	00110000
C11 ON	01000100	00001000
C11 OFF	01000100	00101000
C12 ON	01000100	00011000
C12 OFF	01000100	00111000
C13 ON	01000100	01000000
C13 OFF	01000100	01100000
C14 ON	01000100	01010000
C14 OFF	01000100	01110000
C15 ON	01000100	01001000
C15 OFF	01000100	01101000
C16 ON	01000100	01011000
C16 OFF	01000100	01111000
C BRIGHT 005	01000000	10001000
C DIM 005	01000000	10011000
D1 ON	01010000	00000000
D1 OFF	01010000	00100000
D2 ON	01010000	00010000
D2 OFF	01010000	00110000
D3 ON	01010000	00001000
D3 OFF	01010000	00101000
D4 ON	01010000	00011000
D4 OFF	01010000	00111000

D5 ON	01010000	01000000
D5 OFF	01010000	01100000
D6 ON	01010000	01010000
D6 OFF	01010000	01110000
D7 ON	01010000	01001000
D7 OFF	01010000	01101000
D8 ON	01010000	01011000
D8 OFF	01010000	01111000
D9 ON	01010100	00000000
D9 OFF	01010100	00100000
D10 ON	01010100	00010000
D10 OFF	01010100	00110000
D11 ON	01010100	00001000
D11 OFF	01010100	00101000
D12 ON	01010100	00011000
D12 OFF	01010100	00111000
D13 ON	01010100	01000000
D13 OFF	01010100	01100000
D14 ON	01010100	01010000
D14 OFF	01010100	01110000
D15 ON	01010100	01001000
D15 OFF	01010100	01101000
D16 ON	01010100	01011000
D16 OFF	01010100	01111000
D BRIGHT 005	01010000	10001000
D DIM 005	01010000	10011000
E1 ON	10000000	00000000
E1 OFF	10000000	00100000
E2 ON	10000000	00010000
E2 OFF	10000000	00110000
E3 ON	10000000	00001000
E3 OFF	10000000	00101000
E4 ON	10000000	00011000
E4 OFF	10000000	00111000
E5 ON	10000000	01000000
E5 OFF	10000000	01100000
E6 ON	10000000	01010000
E6 OFF	10000000	01110000
E7 ON	10000000	01001000
E7 OFF	10000000	01101000
E8 ON	10000000	01011000
E8 OFF	10000000	01111000
E9 ON	10000100	00000000
E9 OFF	10000100	00100000
E10 ON	10000100	00010000
E10 OFF	10000100	00110000
E11 ON	10000100	00001000
E11 OFF	10000100	00101000
E12 ON	10000100	00011000
E12 OFF	10000100	00111000
E13 ON	10000100	01000000
E13 OFF	10000100	01100000
E14 ON	10000100	01010000
E14 OFF	10000100	01110000
E15 ON	10000100	01001000
E15 OFF	10000100	01101000
E16 ON	10000100	01011000

E16 OFF	10000100	01111000
E BRIGHT 005	10000000	10001000
E DIM 005	10000000	10011000
F1 ON	10010000	00000000
F1 OFF	10010000	00100000
F2 ON	10010000	00010000
F2 OFF	10010000	00110000
F3 ON	10010000	00001000
F3 OFF	10010000	00101000
F4 ON	10010000	00011000
F4 OFF	10010000	00111000
F5 ON	10010000	01000000
F5 OFF	10010000	01100000
F6 ON	10010000	01010000
F6 OFF	10010000	01110000
F7 ON	10010000	01001000
F7 OFF	10010000	01101000
F8 ON	10010000	01011000
F8 OFF	10010000	01111000
F9 ON	10010100	00000000
F9 OFF	10010100	00100000
F10 ON	10010100	00010000
F10 OFF	10010100	00110000
F11 ON	10010100	00001000
F11 OFF	10010100	00101000
F12 ON	10010100	00011000
F12 OFF	10010100	00111000
F13 ON	10010100	01000000
F13 OFF	10010100	01100000
F14 ON	10010100	01010000
F14 OFF	10010100	01110000
F15 ON	10010100	01001000
F15 OFF	10010100	01101000
F16 ON	10010100	01011000
F16 OFF	10010100	01111000
F BRIGHT 005	10010000	10001000
F DIM 005	10010000	10011000
G1 ON	10100000	00000000
G1 OFF	10100000	00100000
G2 ON	10100000	00010000
G2 OFF	10100000	00110000
G3 ON	10100000	00001000
G3 OFF	10100000	00101000
G4 ON	10100000	00011000
G4 OFF	10100000	00111000
G5 ON	10100000	01000000
G5 OFF	10100000	01100000
G6 ON	10100000	01010000
G6 OFF	10100000	01110000
G7 ON	10100000	01001000
G7 OFF	10100000	01101000
G8 ON	10100000	01011000
G8 OFF	10100000	01111000
G9 ON	10100100	00000000
G9 OFF	10100100	00100000
G10 ON	10100100	00010000
G10 OFF	10100100	00110000

G11 ON	10100100	00001000
G11 OFF	10100100	00101000
G12 ON	10100100	00011000
G12 OFF	10100100	00111000
G13 ON	10100100	01000000
G13 OFF	10100100	01100000
G14 ON	10100100	01010000
G14 OFF	10100100	01110000
G15 ON	10100100	01001000
G15 OFF	10100100	01101000
G16 ON	10100100	01011000
G16 OFF	10100100	01111000
G BRIGHT 005	10100000	10001000
G DIM 005	10100000	10011000
H1 ON	10110000	00000000
H1 OFF	10110000	00100000
H2 ON	10110000	00010000
H2 OFF	10110000	00110000
H3 ON	10110000	00001000
H3 OFF	10110000	00101000
H4 ON	10110000	00011000
H4 OFF	10110000	00111000
H5 ON	10110000	01000000
H5 OFF	10110000	01100000
H6 ON	10110000	01010000
H6 OFF	10110000	01110000
H7 ON	10110000	01001000
H7 OFF	10110000	01101000
H8 ON	10110000	01011000
H8 OFF	10110000	01111000
H9 ON	10110100	00000000
H9 OFF	10110100	00100000
H10 ON	10110100	00010000
H10 OFF	10110100	00110000
H11 ON	10110100	00001000
H11 OFF	10110100	00101000
H12 ON	10110100	00011000
H12 OFF	10110100	00111000
H13 ON	10110100	01000000
H13 OFF	10110100	01100000
H14 ON	10110100	01010000
H14 OFF	10110100	01110000
H15 ON	10110100	01001000
H15 OFF	10110100	01101000
H16 ON	10110100	01011000
H16 OFF	10110100	01111000
H BRIGHT 005	10110000	10001000
H DIM 005	10110000	10011000
I1 ON	11100000	00000000
I1 OFF	11100000	00100000
I2 ON	11100000	00010000
I2 OFF	11100000	00110000
I3 ON	11100000	00001000
I3 OFF	11100000	00101000
I4 ON	11100000	00011000
I4 OFF	11100000	00111000
I5 ON	11100000	01000000

I5 OFF	11100000	01100000
I6 ON	11100000	01010000
I6 OFF	11100000	01110000
I7 ON	11100000	01001000
I7 OFF	11100000	01101000
I8 ON	11100000	01011000
I8 OFF	11100000	01111000
I9 ON	11100100	00000000
I9 OFF	11100100	00100000
I10 ON	11100100	00010000
I10 OFF	11100100	00110000
I11 ON	11100100	00001000
I11 OFF	11100100	00101000
I12 ON	11100100	00011000
I12 OFF	11100100	00111000
I13 ON	11100100	01000000
I13 OFF	11100100	01100000
I14 ON	11100100	01010000
I14 OFF	11100100	01110000
I15 ON	11100100	01001000
I15 OFF	11100100	01101000
I16 ON	11100100	01011000
I16 OFF	11100100	01111000
I BRIGHT 005	11100000	10001000
I DIM 005	11100000	10011000
J1 ON	11110000	00000000
J1 OFF	11110000	00100000
J2 ON	11110000	00010000
J2 OFF	11110000	00110000
J3 ON	11110000	00001000
J3 OFF	11110000	00101000
J4 ON	11110000	00011000
J4 OFF	11110000	00111000
J5 ON	11110000	01000000
J5 OFF	11110000	01100000
J6 ON	11110000	01010000
J6 OFF	11110000	01110000
J7 ON	11110000	01001000
J7 OFF	11110000	01101000
J8 ON	11110000	01011000
J8 OFF	11110000	01111000
J9 ON	11110100	00000000
J9 OFF	11110100	00100000
J10 ON	11110100	00010000
J10 OFF	11110100	00110000
J11 ON	11110100	00001000
J11 OFF	11110100	00101000
J12 ON	11110100	00011000
J12 OFF	11110100	00111000
J13 ON	11110100	01000000
J13 OFF	11110100	01100000
J14 ON	11110100	01010000
J14 OFF	11110100	01110000
J15 ON	11110100	01001000
J15 OFF	11110100	01101000
J16 ON	11110100	01011000
J16 OFF	11110100	01111000

J BRIGHT 005	11110000	10001000
J DIM 005	11110000	10011000
K1 ON	11000000	00000000
K1 OFF	11000000	00100000
K2 ON	11000000	00010000
K2 OFF	11000000	00110000
K3 ON	11000000	00001000
K3 OFF	11000000	00101000
K4 ON	11000000	00011000
K4 OFF	11000000	00111000
K5 ON	11000000	01000000
K5 OFF	11000000	01100000
K6 ON	11000000	01010000
K6 OFF	11000000	01110000
K7 ON	11000000	01001000
K7 OFF	11000000	01101000
K8 ON	11000000	01011000
K8 OFF	11000000	01111000
K9 ON	11000100	00000000
K9 OFF	11000100	00100000
K10 ON	11000100	00010000
K10 OFF	11000100	00110000
K11 ON	11000100	00001000
K11 OFF	11000100	00101000
K12 ON	11000100	00011000
K12 OFF	11000100	00111000
K13 ON	11000100	01000000
K13 OFF	11000100	01100000
K14 ON	11000100	01010000
K14 OFF	11000100	01110000
K15 ON	11000100	01001000
K15 OFF	11000100	01101000
K16 ON	11000100	01011000
K16 OFF	11000100	01111000
K BRIGHT 005	11000000	10001000
K DIM 005	11000000	10011000
L1 ON	11010000	00000000
L1 OFF	11010000	00100000
L2 ON	11010000	00010000
L2 OFF	11010000	00110000
L3 ON	11010000	00001000
L3 OFF	11010000	00101000
L4 ON	11010000	00011000
L4 OFF	11010000	00111000
L5 ON	11010000	01000000
L5 OFF	11010000	01100000
L6 ON	11010000	01010000
L6 OFF	11010000	01110000
L7 ON	11010000	01001000
L7 OFF	11010000	01101000
L8 ON	11010000	01011000
L8 OFF	11010000	01111000
L9 ON	11010100	00000000
L9 OFF	11010100	00100000
L10 ON	11010100	00010000
L10 OFF	11010100	00110000
L11 ON	11010100	00001000

L11 OFF	11010100	00101000
L12 ON	11010100	00011000
L12 OFF	11010100	00111000
L13 ON	11010100	01000000
L13 OFF	11010100	01100000
L14 ON	11010100	01010000
L14 OFF	11010100	01110000
L15 ON	11010100	01001000
L15 OFF	11010100	01101000
L16 ON	11010100	01011000
L16 OFF	11010100	01111000
L BRIGHT 005	11010000	10001000
L DIM 005	11010000	10011000
M1 ON	00000000	00000000
M1 OFF	00000000	00100000
M2 ON	00000000	00010000
M2 OFF	00000000	00110000
M3 ON	00000000	00001000
M3 OFF	00000000	00101000
M4 ON	00000000	00011000
M4 OFF	00000000	00111000
M5 ON	00000000	01000000
M5 OFF	00000000	01100000
M6 ON	00000000	01010000
M6 OFF	00000000	01110000
M7 ON	00000000	01001000
M7 OFF	00000000	01101000
M8 ON	00000000	01011000
M8 OFF	00000000	01111000
M9 ON	00000100	00000000
M9 OFF	00000100	00100000
M10 ON	00000100	00010000
M10 OFF	00000100	00110000
M11 ON	00000100	00001000
M11 OFF	00000100	00101000
M12 ON	00000100	00011000
M12 OFF	00000100	00111000
M13 ON	00000100	01000000
M13 OFF	00000100	01100000
M14 ON	00000100	01010000
M14 OFF	00000100	01110000
M15 ON	00000100	01001000
M15 OFF	00000100	01101000
M16 ON	00000100	01011000
M16 OFF	00000100	01111000
M BRIGHT 005	00000000	10001000
M DIM 005	00000000	10011000
N1 ON	00010000	00000000
N1 OFF	00010000	00100000
N2 ON	00010000	00010000
N2 OFF	00010000	00110000
N3 ON	00010000	00001000
N3 OFF	00010000	00101000
N4 ON	00010000	00011000
N4 OFF	00010000	00111000
N5 ON	00010000	01000000
N5 OFF	00010000	01100000

N6 ON	00010000	01010000
N6 OFF	00010000	01110000
N7 ON	00010000	01001000
N7 OFF	00010000	01101000
N8 ON	00010000	01011000
N8 OFF	00010000	01111000
N9 ON	00010100	00000000
N9 OFF	00010100	00100000
N10 ON	00010100	00010000
N10 OFF	00010100	00110000
N11 ON	00010100	00001000
N11 OFF	00010100	00101000
N12 ON	00010100	00011000
N12 OFF	00010100	00111000
N13 ON	00010100	01000000
N13 OFF	00010100	01100000
N14 ON	00010100	01010000
N14 OFF	00010100	01110000
N15 ON	00010100	01001000
N15 OFF	00010100	01101000
N16 ON	00010100	01011000
N16 OFF	00010100	01111000
N BRIGHT 005	00010000	10001000
N DIM 005	00010000	10011000
O1 ON	00100000	00000000
O1 OFF	00100000	00100000
O2 ON	00100000	00010000
O2 OFF	00100000	00110000
O3 ON	00100000	00001000
O3 OFF	00100000	00101000
O4 ON	00100000	00011000
O4 OFF	00100000	00111000
O5 ON	00100000	01000000
O5 OFF	00100000	01100000
O6 ON	00100000	01010000
O6 OFF	00100000	01110000
O7 ON	00100000	01001000
O7 OFF	00100000	01101000
O8 ON	00100000	01011000
O8 OFF	00100000	01111000
O9 ON	00100100	00000000
O9 OFF	00100100	00100000
O10 ON	00100100	00010000
O10 OFF	00100100	00110000
O11 ON	00100100	00001000
O11 OFF	00100100	00101000
O12 ON	00100100	00011000
O12 OFF	00100100	00111000
O13 ON	00100100	01000000
O13 OFF	00100100	01100000
O14 ON	00100100	01010000
O14 OFF	00100100	01110000
O15 ON	00100100	01001000
O15 OFF	00100100	01101000
O16 ON	00100100	01011000
O16 OFF	00100100	01111000
O BRIGHT 005	00100000	10001000

O DIM 005	00100000	10011000
P1 ON	00110000	00000000
P1 OFF	00110000	00100000
P2 ON	00110000	00010000
P2 OFF	00110000	00110000
P3 ON	00110000	00001000
P3 OFF	00110000	00101000
P4 ON	00110000	00011000
P4 OFF	00110000	00111000
P5 ON	00110000	01000000
P5 OFF	00110000	01100000
P6 ON	00110000	01010000
P6 OFF	00110000	01110000
P7 ON	00110000	01001000
P7 OFF	00110000	01101000
P8 ON	00110000	01011000
P8 OFF	00110000	01111000
P9 ON	00110100	00000000
P9 OFF	00110100	00100000
P10 ON	00110100	00010000
P10 OFF	00110100	00110000
P11 ON	00110100	00001000
P11 OFF	00110100	00101000
P12 ON	00110100	00011000
P12 OFF	00110100	00111000
P13 ON	00110100	01000000
P13 OFF	00110100	01100000
P14 ON	00110100	01010000
P14 OFF	00110100	01110000
P15 ON	00110100	01001000
P15 OFF	00110100	01101000
P16 ON	00110100	01011000
P16 OFF	00110100	01111000
P BRIGHT 005	00110000	10001000
P DIM 005	00110000	10011000